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(54) Article gripper.

(57) An article gripper with a fixed jaw (54) has a movable jaw (53) mounted on reed springs (50, 57). Deflection of the movable jaw permits the article (52) to enter and exit the gripper. The movable jaw (53) has an inlet cam surface (55) and an outlet cam surface (59), configured so that a relatively low-level inlet force deflects the jaw and reeds laterally, while a relatively higher-level outlet, or removal, force is directed parallel to the reed springs causing the jaw to behave stiffly and thus resist pull-out of the article.

Fig 24

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Article Gripper

The invention relates broadly to the field of article grippers and, in particular, the invention relates to tool grippers used for tool storage magazines, and to article gripper mechanisms such as part loaders which may be used with machine tools.

A variety of article grippers have been used in conjunction with tool handling and part handling machinery, where the tool grippers are often configured as having a pair of fingers or jaws which may be opened and closed in a pincher-like movement to grasp the desired article. Most often, the gripper fingers are relatively powered with respect to one another by fluid power actuators such as air cylinders. The devices are also frequently fitted with a "fail-safe" mechanism to maintain grasp of the article in the event of a power failure.

The prior art devices are typically of complex construction, having high cost and relatively high maintenance requirements to insure reliability.

Applicants have studied the inherent problems associated with applying article grippers in a variety of spatial orientations, and have determined that modern requirements for machine tools, in particular, dictate that low cost be an objective in the overall design of the device.

Applicants have designed an article gripper which uses certain spring elements arranged in a manner so that the removal force to extract a tool, for instance, from the article gripper is substantially higher than the insertion force to introduce a tool into the gripper.

The design achieved lends itself well to an article gripper made of one-piece homogeneous material such as an engineering plastic, for example, 'Delrin" acetal resin.

Further, the design achieved lends itself well to a gripper which may be machined from plastic stock, or which may be readily reproduced through gripper moulding techniques, such as the plastic injection moulding process.

It is therefore an object of the present invention to produce an article gripper having a part removal force which is substantially greater than a part insertion force.

The invention is shown embodied in an article gripper which has a body and means for mounting the body to a gripper carrier. The body has first and second jaws oppositely disposed about a reference axis for containing a desired article, where the first jaw is deflectable from the axis. The body also contains reed spring means including a plurality of parallel reed springs which have a low spring constant and are shiftable in a lateral direction while the reed springs have a relatively high spring constant in a longitudinal direction, i.e. parallel to the reed springs. The reed springs serve to mount the first jaw to the body. An opening is formed between the jaws for insertion and removal of an article as the jaws and article are relatively moved along the axis, and the first jaw has:

(a) first cam means for contacting an article being inserted into the gripper; and

(b) second cam means for contacting an article being removed from the gripper.

A first line of action is defined through the first cam means in a direction transverse to the reed springs, so that the first line of action will recieve an insertion force component as an insertion force is applied to an article along the reference axis. A second line of action is defined through the second cam means in a direction approximately parallel to the reed springs, where the second line of action will receive a removal force component as a removal force is applied to an article along the reference axis. The insertion force component and the removal force component will each deflect the first jaw from the reference axis, and the ratio of the removal force to the insertion force is greater than 1.

In an alternate embodiment, the spring mounted jaw is duplicated for the second jaw position, to provide a gripper which is symmetrical about the reference axis, wherein both jaws are deflected from the axis. In the second embodiment, as with the first, the ratio of the removal force to the insertion is greater than 1.

Preferably said ratio is greater than 1.1, and preferably lies in the range 1.2 to 2.6, conveniently between 1.3 and 2.4.

There will now be given detailed descriptions, to be read with reference to the accompanying drawings, of various embodiments which have been selected for the purposes of illustrating the invention by way of example.

In the accompanying drawings:

Figure 1 is a front perspective view of a multi-axis horizontal machining centre having a chain-type tool storage matrix;

FIGURE 1a is a front elevational view of a disc-type tool storage matrix;

FIGURE 2 is a side elevational view of a tool and toolholder;

FIGURES 3a-3e show a sequence of tool changing moves;

FIGURE 4 is a front elevational view of a tool gripper which is a first embodiment of the invention;

FIGURE 5 is a side elevational view of the tool gripper of Figure 4;

FIGURE 6 is a bottom plan view of the tool gripper of Figure 4;

FIGURE 7 is a sectional view through the tool gripper, taken along the line 7-7 of Figure 4;

FIGURE 8 is a sectional view through a gripper jaw, taken along the line 8-8 of Figure 4;

FIGURE 9 is a schematic view of the tool gripper of Figure 4;

FIGURE 10 is a view of the tool gripper of Figure 9, showing a tool being inserted;

FIGURE 11 is a view of the gripper of Figure 9, showing a tool being removed;

FIGURE 12 is a front elevational view of a symmetrical tool gripper;

FIGURE 13 is a graph showing tool removal force versus tool travel for a moulded tool gripper;

FIGURE 14 is a side elevational view of a chain-type tool carrier, having a plurality of tool grippers;

FIGURE 15 is a partial front elevational view of a drive sprocket for moving plural chains;

FIGURE 16 is a front elevational view of an injection moulded tool gripper;

FIGURE 17 is a bottom plan view of the moulded tool gripper of Figure 16;

FIGURE 18 is a top plan view of the moulded tool gripper of Figure 16; FIGURE 19 is a right side elevational view of the moulded tool gripper of Figure 16;

FIGURE 20 is a left side elevational view of the moulded tool gripper of Figure 16;

FIGURE 21 is a rear elevational view of the moulded tool gripper of Figure 16;

FIGURE 22 is a sectional view taken along the line 22-22 of Figure 16;

FIGURE 23 is an elevational sectional view taken along the line 23-23 of Figure 16;

FIGURE 24 is a perspective view of a tool gripper in a drive key system;

FIGURE 25 is a perspective view of a tool gripper system in a vertical machining centre;

FIGURE 26 is an exploded view of the tool gripper of Figure 25; and

FIGURE 27 is a perspective view of a turning machine employing grippers in a workpiece loader.

Figure 1 of the drawings shows a machine 10 configured as a horizontal machining centre used in conjunction with the present invention. The machine 10 has a rear base 11 which carries a column 12 slidable along an X-axis, while the column 12, in turn, carries a vertical saddle 13, i.e. movable in the Y direction. The saddle 13, carries a spindle carrier 14 which is movable in a Z direction on the saddle 13, so that a rotary spindle 15 is provided with three mutually-perpendicular coordinates of movement. Suitable drives are shown for propelling the machine components. A machining centre 10 of this configuration is commercially available as model HPMC (High Performance Machining Centre) from Cincinnati Milacron Inc., assignee of this invention. Here it should be noted that while a preferred arrangement of X, Y, and Z movements is shown, other types of horizontal machining centres will provide for the same total three movements for the machine spindle while the discrete elements may vary in their directions of motion. The machine 10 has a front base 16 which is secured in a fixed relationship to the rear base 11 and is suitable for fixturing a workpiece thereon for machining operations. The workpiece and fixturing methods do not comprise part of the present invention and have been ommited for purposes of clarity.

The rear base 11 supports a tool carrier 17 which, in essence, is a chain matrix tool storage mechanisms wherein part-specific tool grippers 18 are positioned along the pitch line 19 of the chain 20. The tool carrier 17 is affixed through a base means 21 to the rear base 11, and the carrier 17 has a drive motor 22 and gear box 23 provided at its upper end for positioning the chain 20 for tool changes. Three representative tool grippers 18 are shown, the centre of which is empty and ready to receive a tool 24 carried by the machine spindle 15. The gripper 18 is vertically positioned in line with the spindle 15, so that an X movement is all that is required to insert the tool 24 into the tool gripper 18.

Referring briefly to Figure 2, a representative tool 25 is depicted, where the actual cutter 26 may be of different types (end mills, drills, etc)., and the cutter 26 is affixed to a common toolholder 27. The toolholder 27 depicted is of a well-known type, known as a "V-flange" toolholder, wherein a circular flange 28 is provided with an annular V-groove 29 for gripping purposes when changing tools. The toolholder 27 has a tapered shank 30, which is received in a cooperating tapered socket 31 of the tool spindle 15. The toolholder 27 is provided with a common retention knob 32 at its rearmost end, so that an internal retention means 33 may draw the toolholder 27 tightly into engagement with the spindle 15. Upper and lower jaw profiles 34, 35 are seen supporting the tool about its flange 24. The internal retention means 33 may be one of a variety of well-known mechanisms and does not form part of this invention, and it will be appreciated by those skilled in the art that the internal retention means 33 of the spindle 15 may be selectively applied to clamp and release the tool at desired times. An example of a tool retention means is shown in U.S. Patent 4,605,349 of K.F. Bone, assigned to Cincinnati Milacron Inc., the assignee of the present invention.

In order to represent the proportions of the inventive grippers to those of ordinary skill in the art, two

common flanged toolholders may be considered as exemplary; a No. 50 taper toolholder, in which the dimensions "D" and "L" are approximately 3.656 in. (9.374 cm.) and 4.362 in. (11.184 cm.), respectively; and a No. 40 taper toolholder, in which "D" and "L" are approximately 2.280 in. (5.846 cm.) and 3.049 in. (7.817 cm.), respectively.

Further, while certain attitudinal references are made -- e.g. "upper" and "lower", etc. -- such references are made only by way of explanation and assistance to the reader, and not by way of limitation to any particular frame of reference. It is contemplated that a variety of toolholders 27 may be utilised in conjunction with the present invention; for example, those having outer surfaces other than the V-flange depicted, and those having straight shanks instead of tapered shanks 30. Figure 1 also shows an automatic control 36; for example, a computer numerical control (CNC) which is used in conjunction with the machine 10 to provide automatic operation. One such control is available from Cincinnati Milacron Inc., the assignee of the present invention, and commercially known as the ACRAMATIC 850 CNC control.

The machine 10 depicted in Figure 1 does not have a separate tool changing arm found in many commercially-available machining centres; rather, the machine makes use of coordinate movements of the spindle 15, cooperating with the tool gripper 18, to accomplish tool changing operations. It will be appreciated by those skilled in the art that a separate tool-changing slide or tool-changing arm can be used with the present invention in certain instances, in accordance with the principles disclosed.

Figure 1a illustrates a disc-type tool matrix 17a, for an alternate, lower-density, storage of tools 25, where a plurality of tool grippers 18 are affixed to a bidirectional rotary disc 37 carried on the rear base 11.

Figures 3a-3e depict a sequence of events for changing tools on the machine 10 of Figure 1, as follows:

Figure 3a shows the spindle 15 being moved radially in the direction of the arrow -- step 1 -- which is an X-axis move of the machine 10. The tool 25a is inserted in the empty gripper 18a with the upper and lower jaws cooperatingly-mated to the flange(Ref. Figure 2).

Figure 3b shows the spindle 15 retracting in the arrow direction -- step 2 -- after the internal retention means releases the tool retention knob. Step 2 is a Z-axis move on the machine 10;

Figure 3c illustrates the next adjacent lower gripper 18b and its respective tool 25b being moved up into alignment with the machine spindle 15 by movement of the tool carrier chain 20 in the direction of the arrow --step 3;

FIGURE 3d shows the spindle 15 advanced into engagement with the succeeding tool 25b, by movement of the spindle 15 in the direction of the arrow -- step 4. At completion of the step 4 movement, the internal retention means is actuated to clamp the tool retention knob;

FIGURE 3e depicts the tool 25b being removed from the tool gripper 18b through movement of the spindle and tool in the direction of the arrow --step 5. The machine 10 is now ready to commence machining operations.

Figure 4 illustrates a front view of a typical tool gripper 38 slightly differing from that shown in Figure 1, as it would appear at the position for tool change. This gripper 38 depicted was machined from "Delrin" 150 acetal resin plate, a well-known engineering thermoplastic. The gripper 38 has a unitary width, and is fitted, on occasion, with an extension block 39, keyed into the main body 40 of the gripper 38 and held by cap screws 41 inserted from the reverse side. The extension block 39 is described with Figure 5, below. The gripper shape depicted in Figure 4 is referred to as an "asymmetrical" design, i.e. where the upper and lower jaws 42, 43 are not identical and are not identically supported on the main body 40 of the gripper 38. The lower jaw 43 is provided with a quarter-round cut-out 44 which is configured to the diametral cross-section of the V-flange 28 of the toolholder 27 (see Figure 5). The outboard end 45 of the lower jaw 43 runs tangent to the cut-out 44 and is of a cooperating cross-section, as well. The lower jaw 43 is integral with the main body 40, relatively stiff, and of unit width for supporting tools which must be aligned in a vertical direction with the machine spindle 15 for successive tool changes.

Referring to Figure 5, since the gripper 38 is of unit width, the upper and lower jaws 42, 43 lie in the same plane. In the event that lightweight tools are employed, or tools which are especially balanced about the lower jaw 43, it may be necessary to only use the gripper body 40 without the extension block 39. In such case, the plate-like body 40 would be simply pinned to the pin joints of a single chain and would not experience problems associated with overturning movements, i.e. which would tend to cock the gripper out of its normal attitude. When heavy, overhanging loads are seen on various tools and toolholders, it may sometimes become desirable to utilise the extension block 39 which provides, at its outermost end, a pair of pin joint holes 46 in line with like holes (not shown) in the rear of the gripper body 40. In this case, tandem chains 47 are employed (see Figure 14), and the gripper 38 and block 39 are pinned, as a unit, to both chains 47. In certain cases, it may also be desirable to laminate stiffening plates 48 to the gripper 38 in the manner shown in Figure 26, to prevent out-of-plane distortion of the jaws, 42, 43.

The upper jaw 42 of the gripper 38 has an arcuate gripper surface 49 which, like the lower jaw cut-out

44, is configured to the V-flange cross-section of the toolholder, with the maximum dimension "D" of a tool flange 28, occurring at the central, gripped position and from which, generally, the radius-of-curvature of each jaw is swung. A certain amount of wrap-around to angle theta, right and left of centre, here chosen as approximately 30°, is provided so that the tool will be prevented from inadvertent radial movement, once centred in the gripped position.

The upper jaw 42 is mounted to the main body 40 of the gripper 38 by intergral reed springs 50 which are parallel to one another and of unit width, as shown in Figure 7. In the support of a first member on a second member, lateral spring loading, i.e. normal to the reed planes, will cause a lateral shift of the first member while maintaining its attitude (in case of equal-length reeds). In such case, equal reeds will experience equal stresses. The reed springs 50 depicted are of slightly unequal lengths, to fit a particular design space, and it is intended that the upper jaw 42 will flex laterally as the reed springs 50 are laterally deflected. When experiencing pure lateral loading, it may be desired that the bending stress in all of the reed springs 50 remain nearly constant, for good life.

The stress in the laterally-deflected reeds may be computed according to the following formula for stress:

$$S = \frac{3Eyd}{L^2}$$

and, where S is a constant, chosen as 6000 psi.,

$$\left(4.052 \times \frac{10^3 nt}{cm^2}\right)$$

d = thickness of reed, inches (cm);
L = length of reed, inches (cm);
y = deflection of reed, inches (cm); and
E = modulus of elasticity 334,000 psi

$$\left(2.256 \times \frac{10^5 nt}{cm^2}\right)$$

Using

$$d = \frac{L^2 S}{3Ey},$$

the following table results for computing reed thickness, d, from the constant stress model:

Reed No	@ L. Inches (cm)	d. Inches (cm)
1	3.40 (8.635)	.138 (.350)
2	3.3 (8.381)	.130 (.330)
3	3.2 (8.127)	.122 (.310)
4	3.1 (7.873)	.115 (.292)
5	3.0 (7.619)	.107 (.272)
6	2.9 (7.365)	.101 (.257)
7	2.8 (7.111)	.094 (.239)
8	2.73 (6.933)	.090 (.229)
9	2.70 (6.857)	.087 (.221)

L may be determined by layout as in the present example, since it will be appreciated that the maximum height of the gripper is limited when it is expected that each corresponding chain link carry a tool gripper. When adjacent corresponding links are left open the tool gripper may of course, be of large size.

Referring to Figures 9, 10 and 11 in conjunction with one another, the simplified grippers 51 depicts only three reed springs, so the invention is easily realised. Figure 9 shows a representative cylindrical toolholder 52 gripped between the upper and lower jaws, 53, 54 and it will be appreciated that the jaws 53, 54 may have a variety of cut-outs so long as the toolholder 52 is adequately retained. It will also be appreciated that the tooholder 52 need not be round, but rather, a variety of cross-sections may be gripped as well, for example, 3 and 4-lobed ploygon cross-sections. Figure 9 illustrates that the upper jaw 53 is provided with a first cam means or inlet cam surface 55 (in some cases a simple chamfer) which will be contacted by an incoming toolholder 52, thereby establishing a line of contact 56 between the jaw 53 and toolholder 52 along which a tool insertion force component "TIFC" will be directed as the gripper 51 and toolholder 52 are relatively moved toward one another under influence of a tool insertion force "TIF" applied along a horizontal radial line, or reference axis "RA" passing through the centre of the toolholder. The insertion force component "TIFC" is arranged to be principally directed in a direction transverse to the reed springs, to cause them to shift in a lateral direction; see Figure 10, where the tool insertion force "TIF" is depicted by the broad arrow. The upper jaw 53 will tend to be shifted to the left and upward in the figure, relative to a reference point "B" defined at the base of the reed springs 57.

The gripping cut-out 58 of the upper jaw 53 is provided with a second cam means, or outlet cam surface 59, which interacts with the outer surface of the toolholder 52 as the toolholder 52 is removed from the gripper 51, thereby creating a line of action 60 for a tool removal force component "TRFC" -- at least during initial movement of the toolholder 52 out of the tool gripper 51. The reed springs 57 are arrayed parallel to the tool removal force component "TRFC" and line of action 60 at angle aplha (approximately 30°) so that the reed springs 57 will tend not to undergo a lateral shift, i.e. in their direction of relatively weak spring constant, but rather, the force will be applied substantially longitudinally to the reed springs, manifesting itself both in the form of a direct tensil force, and an overturning moment which tends to put a compressive stress on the leftmost reed springs. Referring to Figure 4, the leftmost springs may therefore be provided with a slightly thicker centre portion or pad 50a to resist any buckling of the reed springs 50 under compressive load, thereby reinforcing one another. Figure 9 schematically shows that the removal force "TRF" will tend to bend the upper jaw about a reference point "A", i.e. the jaw 53 tends to behave as a stiff cantilever beam. Figure 11 shows a tool removal force "TRF" applied in the direction of the broad arrow, causing the jaw 53 to deflect upwardly a distance, delta 2.

As stated above, with reference to Figure 4, the preferred embodiment for a gripper 38 for use in the tool carrier 17 of Figure 1 (see also Figures 9-11), comprises an asymmetrical shape, where the lower jaw 43 is relatively rigid with the main body 40 and is aligned with the tool path (i.e. parallel to the reference axis "RA") at the pick-up position. Subsequently, as the grippers 38 migrate to the opposite side of the chain circuit, opposite the tool pick-up, gravitational forces will act against the deflectable jaw 42, as the gripper 38 is inverted. However, it is not necesssary to maintain the precise centering of the toolholder on the inverted grippers 38 remote from the toolchanging zone. Additionally, it will be appreciated that, at the lower bend of the chain circuit in Figure 1, the weight of the tool will tend to open the jaws, but the relatively stiff spring constant of the reed springs in the longitudinal direction will serve to maintain the tool in position in the manner described with Figure 11.

Figure 12, however, is a modified, symmetrical embodiment of a tool gripper 61, wherein both the upper and lower jaws 62, 63 are spring-mounted to the gripper body 64 through like pluralities of parallel

reed springs 65, to create a mirror-image structure about the reference axis "RA".

It is noted that a variety of constructional materials may be used for the gripper body, but in the preferred embodiment the engineering plastic "Delrin" is used. It is contemplated that many types of plastics would be suitable for use, at the choice of the designer; for example, a variety of thermoplastic resins and thermoset resins. Further, materials may be utilised in bar stock and plate forms, or in moulded shapes such as may be produced, for example, by the injection moulding process. Depending on design requirements, certain reinforcements -- for example, glass fibres -- may conjoin with the resins to enhance performance of the gripper.

Figure 13 is a graph plotting the gripper tool removal force "TRF" versus travel of the tool outward from the zero, or gripped position. The four curves depicted are for the same part; an injection moulded gripper depicted in Figures 16-21. Similar curves could be plotted for other sizes of moulded grippers and machined grippers, alike. The four curves depicted show the gripper: as a NEW PART; at 25,000 CYCLES; at 118,000 CYCLES; and at 245,000 CYCLES. Considering the lower jaw as essentially rigid, the removal spring rate for the upper jaw is nearly linear, and is expressed in the initial, positive-slope of the curve 66 from zero. The peak force 67 is lessened somewhat during the life testing of the part, and, it will be noted that a portion 68 of the removal force curve is actually a negative number, i.e. where the line dips below the X ordinate. This plotted negative force portion is apparently realised because the inherent springiness of the gripper jaws tends to squeeze -- and thus "shoot" -- the part from the jaws due to spring-back of the jaws against the tool diameter.

The table below is fatigue test data from a tool gripper generally of the kind illustated in Figure 4, indicating the tool removal force and the tool insertion force, and the ratio therebetween.

TABLE 1

Fatigue Test Data from No. 50 Taper Tool Gripper				
Part Condition	Number of Cycles	Removal Force (kg)	Insertion Force (kg)	Ratio
As machined	0	28	17	1.6
Cimcool film from coolant spray	30,500	21	13	1.6
wear surfaces water rinsed	30,500	25	14	1.8
wear surfaces solvent wiped & dry	70,000	33	15	2.2
Cimcool film (semi-wet)	109,00	25	13	1.9
wear surfaces solvent wiped & dry	109,000	39	16	2.4

TABLE 11

Fatigue Test Data from No. 40 Taper Tool Gripper				
Part Condition	Number of Cycles	Removal Force (kg)	Insertion Force (kg)	Ratio
As machined	0	31	21	1.5
Cimcool film (semi-wet)	31,000	24	16	1.5
wear surfaces solvent wiped	31,000	38	26	1.5
Cimcool film (semi-wet)	94,000	26	17	1.5
wear surfaces solvent wiped	94,000	41	25	1.6
Cimcool film (semi-wet)	222,000	21	15	1.4
wear surfaces solvent wiped)	222,000	31	22	1.4

Figure 14 is a side view of the tool carrier 17 of Figure 1, illustrating in detail how grippers 38 could be attached to the links of tandem chains 47. The chains 47 have a roller 69 journalled on a link pin 70 which extends through inner and outer link plates 71, 72 and is affixed in the tool gripper 38 and its extension 39. The chains 47 are trained over spaced-apart drive sprockets 73, 74.

Figures 16-23 describe a moulded version of a tool gripper 75 with certain changes to the design to facilitate easily the moulding process. The gripper extension 76 is integral with the main body 77,with generally cylindrical walls 78 surrounding the pin holes 79. The main stiffening wall 80 of the extension 76 has been thined-out and a cored pocket 81 is formed between the wall 80 and strengthening ribs 81, 82 which stiffen the tubular walls 78. The gripper 75 has a pattern of cored-out sections 83, 89 which extend from both sides to central stiffening web 84 (Figure 23). The parallel reed springs 85 are each of the same length and thickness, extending from a common base line, at the main body 77. The cored sections 83, 89 of the jaws 86, 87 create an "I-beam type cross-section, and the upper jaw 86 is further strengthened with a rib 88 at the point of expected flexure "A", relative to the reed springs 85.

The reverse side of the grippers 75, depicted in Figure 21, is similarly constructed, but the cored openings 89 create ribs which criss-cross the ribs of the front side (shown dotted), for additional strength. This design economises on material, allows for proper cooling, and facilitates gating of the material in the moulds.

A very important feature of the plastic gripper design is that a high pull-out force is achieved without preloading the jaws against the gripped part. Heavily loaded plastic members may tend to lose their preload overtime due to the phenomena of stress relaxation and creep.

Figure 24 depicts a toolholder 90 with 180° opposed keyways 91 in its flanged 92, driven by drive keys 93 affixed to the spindle 94. In machines employing drive keys 93, the spindle 15 is respectively oriented to the same rotary position to change tools 94. To assure that the tools 94 remain in the correct orientation while in storage, the gripper 95 may be manufactured, for example, with a key portion 96 on the lower jaw 97.

Figure 25 illustrates the invention embodied in a vertical machining centre 100 having X, Y, and Z movements, where the machine spindle 101 has its main rotary axis in a vertical orientation. The tool grippers 102 of the tool carrier 103 lie in a horizontal plane to exchange tools 104 at the tool pick-up position. To prevent unwanted tipping of the jaws 105, 106 with respect to the main body 107 of the gripper 102, a pair of stiffening plates 48 are sandwiched with the gripper 102, as shown in Figure 26. Screws 108 passing through the fixed body 107 and the plates 48, are assembled with washers 109 and nuts 110, to maintain a slight clearance between the laminated plates 48 and jaws 105, 106, so that the reed-mounted deflectable jaw 105 can freely operate. The plates 48 have cut-outs 111 to clear the tool 104.

The symmetrical gripper 61 of Figure 12 is likewise applicable to vertical systems (Figure 25), depending on the loads involved and space available along the tool chain.

In still another alternate embodiment, Figure 27, the article gripper 112 is shown in a gantry loader 113 for workpieces 114, often used with turning machines and grinding machines. The loader has a frame, or gantry 115, bridging the machine tool 116, and a slide 117 is movable along the gantry 115 axially of the workpiece 114. The slide 117, in turn, carries a pair of rams 118 movable radially of the workpiece 114, shuttled in see-saw fashion. At the end of the ram 118 is a pair of tandem grippers 119 working as one, for gripping a shaft-like workpiece 114. With shorter workpieces, one gripper may suffice. In certain prior art systems, for example, that disclosed in U.S. Patent 4,348,044 (assigned to Cincinnati Milacron Inc., the assignee of the present invention), the gripper must be powered between open and closed positions. In the depiction of Figure 27, the grippers are forced over the diameter of the workpiece 114 to be loaded, at an insertion force level, and the higher removal force will serve to maintain the grip on the workpiece 114 during its excursion to the machine loading zone. Once loaded between centres, the passive gripper 119 may then be pulled off the workpiece 114 by a longitudinal removal force applied upwardly to the ram. The loading system described achieves the objectives of an effective, low-cost and highly reliable workpiece article gripper.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, or a class or group of substances or compositions, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. An article gripper, comprising:
a body (40, 51), including means (46) for mounting said body to a gripper carrier (17);
first (53) and second (54) jaws on said body (51), oppositely disposed about a reference axis (RA), said first jaw (53) being deflectable from said axis (RA);

spring means (50, 57, 65, 85) for mounting said first jaw (53) to said body (51), said spring means having a relatively low spring constant in a direction laterally of an axis of said spring means, whilst having a relatively high spring constant in a longitudinal direction;
an opening between said jaws for insertion and removal of an article (52) as said jaws (53, 54) and article (52) are relatively moved along said axis (RA);
first cam means (55) on the first jaw (53) for contacting an article (52) being inserted into said gripper;
second cam means (59) on the first jaw (53) for contacting an article (52) being removed from said gripper;
a first line of action (56) defined through the first cam means (55) in a direction transverse to said spring means (50, 57, 65, 85), said first line of action (56) receiving an insertion force component (TIFC) as an insertion force (TIF) is applied to an article (52) along said reference axis (RA);
a second line of action (60) defined through the second cam means (59) in a direction approximately parallel to said spring means, said second line of action (60) receiving a removal force component (TRFC) as a removal force (TRF) is applied to an article (52) along said reference axis (RA);
whereby said insertion force component (TIFC) and said removal force component (TRFC) will deflect said first jaw (53) from said reference axis (RA) and wherein the ratio of the removal force (TRF) to the insertion force (TIF) is greater than one.

2. An article gripper according to Claim 1 wherein said second jaw (54) is solid with said body (51), a gripper surface on said first jaw (53) being so shaped as to cooperatingly mate with an article periphery, and for partial spanning of said article periphery, for holding said article on said second jaw.

3. An article gripper according to Claim 1 wherein said jaws (53, 54) are identical.

4. An article gripper according to any one of the preceding claims wherein said spring means comprises a plurality of parallel reed springs joined for common action.

5. An article gripper, comprising:
a body (40, 51), including means (46) for mounting said body to a gripper carrier (71);
a pair of identical jaw assemblies jaws (53, 54) on said body, oppositely disposed about a reference axis (RA), each jaw assembly comprising:
a jaw (53 or 54) deflectable from said axis (RA);
reed spring means (50, 57, 65, 85) for mounting said jaw (53 or 54) to said body, including a plurality of parallel reed springs joined for common action, said reed springs having a relatively low spring constant and being shiftable in a lateral direction, while having a relatively high spring constant in a longitudinal direction, parallel to said reed springs;
first cam means (55) on the jaw (53) for contacting an article (52) being inserted into said gripper;
second cam means (59) on the jaw (53) for contacting an article (52) being removed from said gripper;
a first line of action (56) defined through the first cam means (55) in a direction transverse to said reed springs, said first line of action receiving an insertion force component (TIFC) as an insertion force (TIF) is applied to an article along said reference axis (RA);
a second line of action (60) defined through the second cam means (59) in a direction approximately parallel to said reed springs, said second line of action receiving a removal force component (TRFC) as a removal force (TRF) is applied to an article (52) along said reference axis (RA);
an opening between said jaws for insertion and removal of an article as said jaws and article are relatively moved along said axis;
whereby said insertion force component (TIFC) and said removal force component (TRFC) will deflect said first jaw from said reference axis and wherein the ratio of the removal force to the insertion force is greater than one.

6. An article gripper according to any one of the preceding claims wherein the ratio of the removal force to the insertion force is greater than 1.1.

7. An article gripper according to any one of the preceding claims wherein said ratio is in the range 1.2 to 2.6, preferably between 1.3 and 2.4.

8. An article gripper according to any one of the preceding claims, being a one-piece construction.

9. An article gripper according to any one of the preceding claims, being of moulded construction.

10. An article gripper according to any one of the preceding claims, constructed of plastics material, such as thermoplastic resin or thermosetting resin.

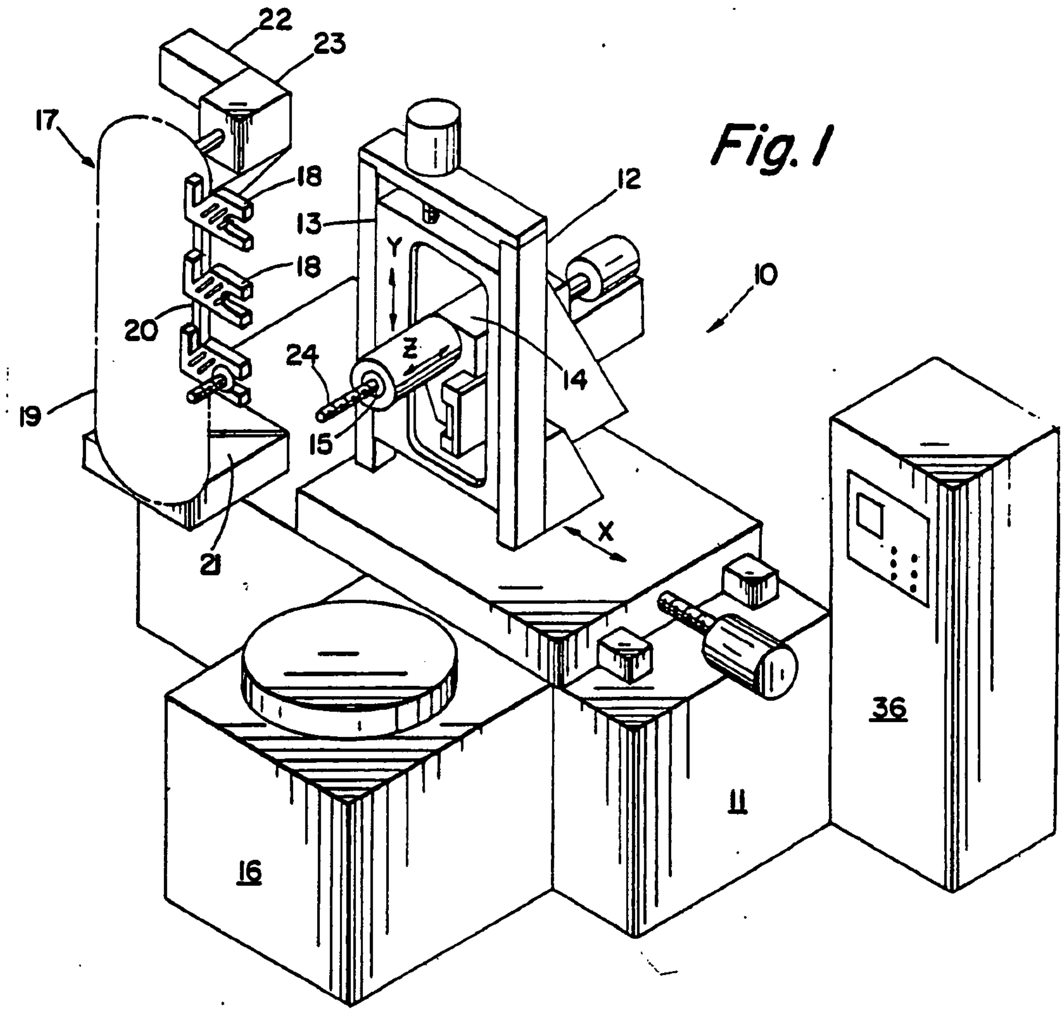
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Fig. 1

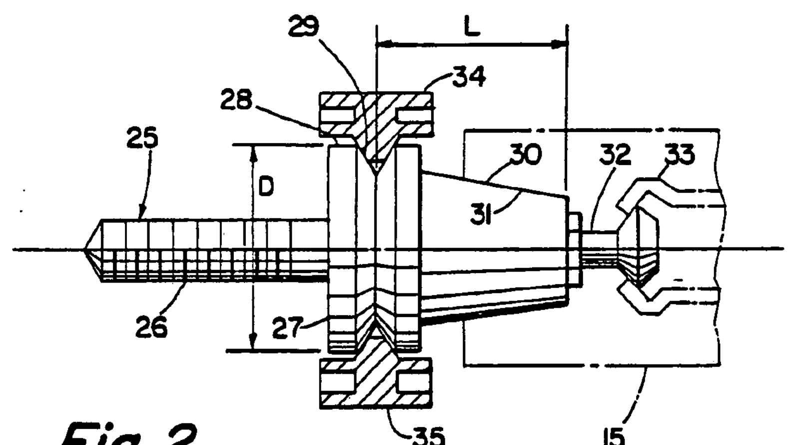
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Fig. 2

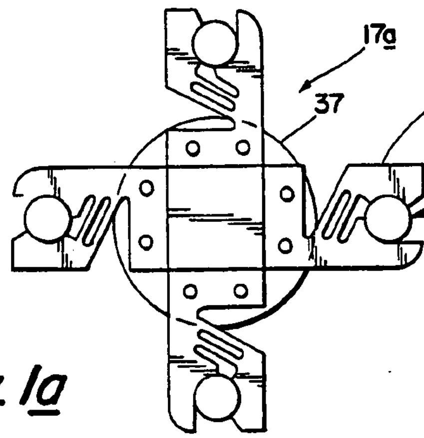


Fig. 1a

Fig. 3a

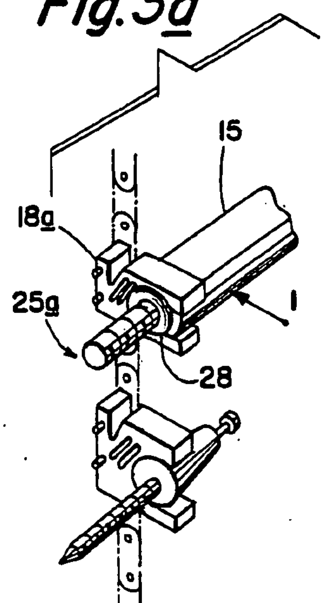


Fig. 3b

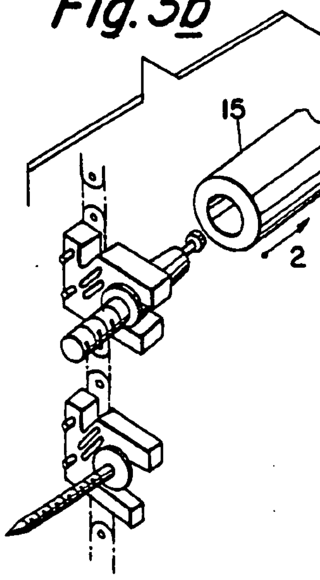
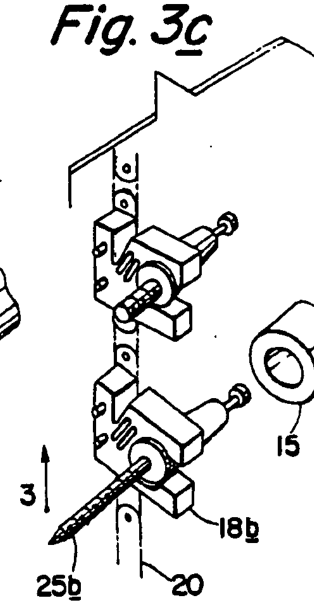


Fig. 3c



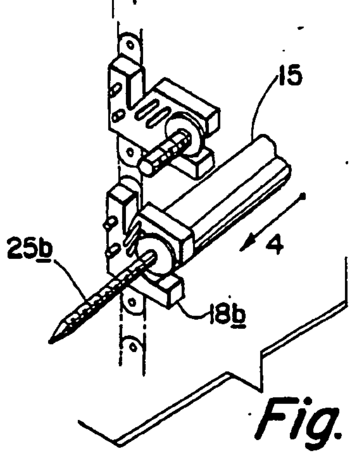


Fig. 3d

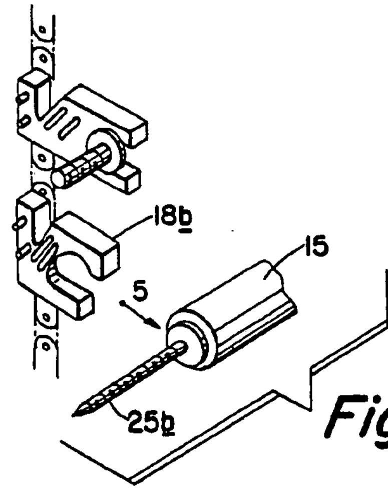


Fig. 3e

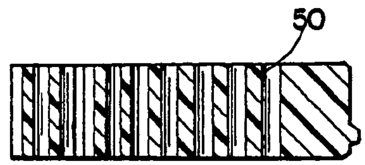
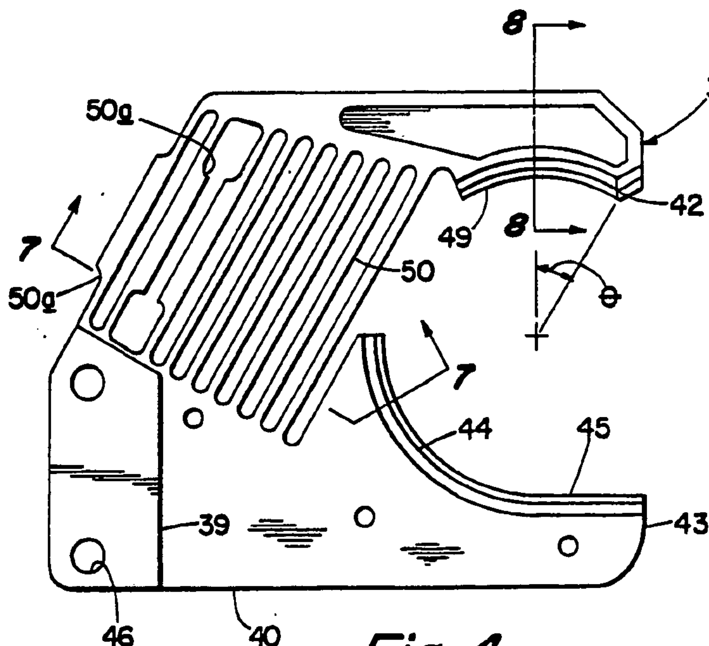


Fig. 7



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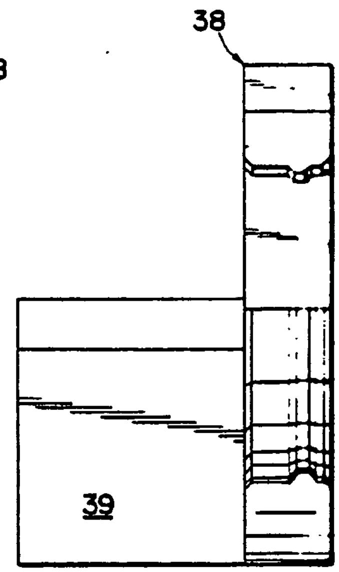

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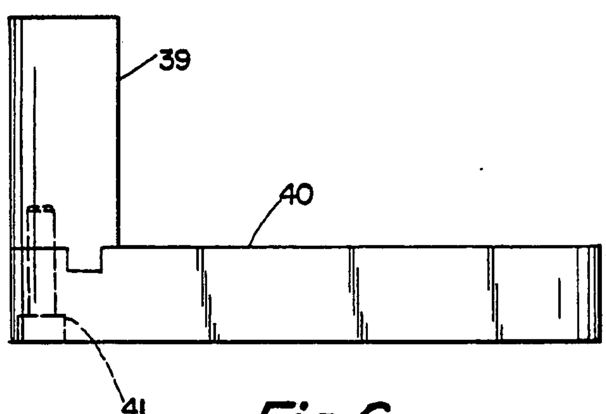

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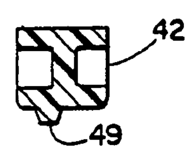

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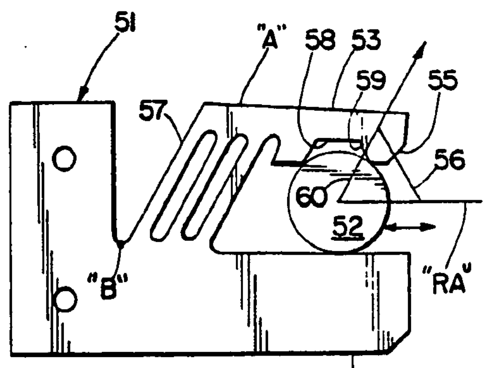
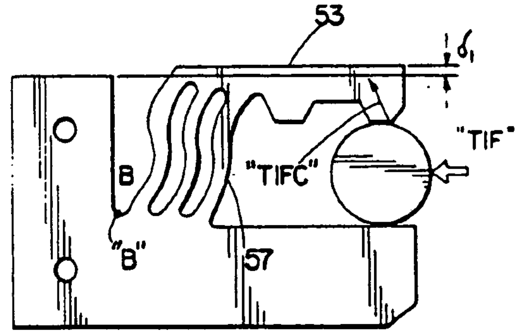


Fig. 9



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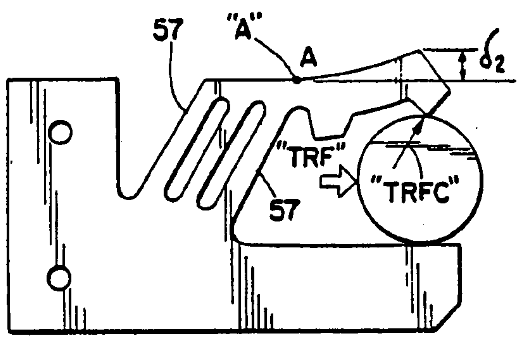
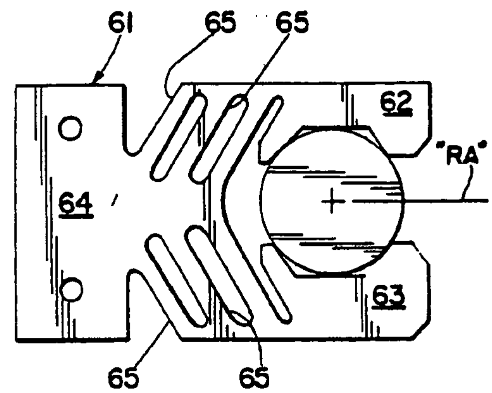


Fig. 11



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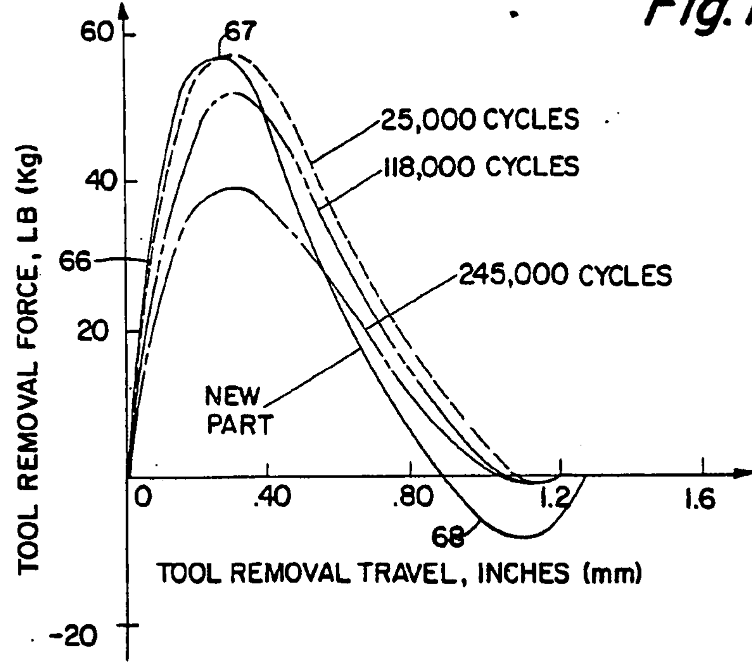
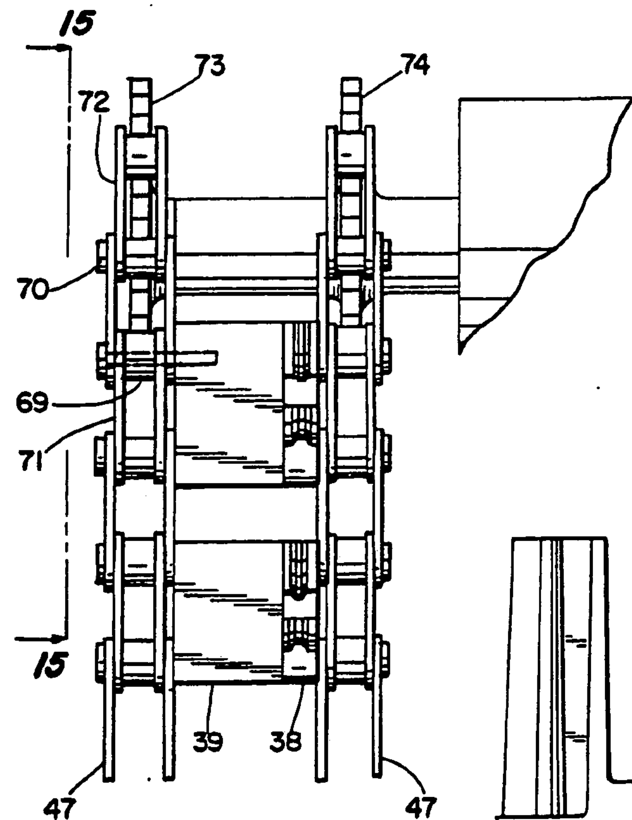


Fig. 13



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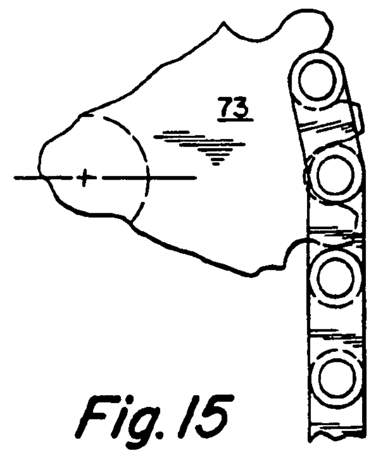


Fig. 15

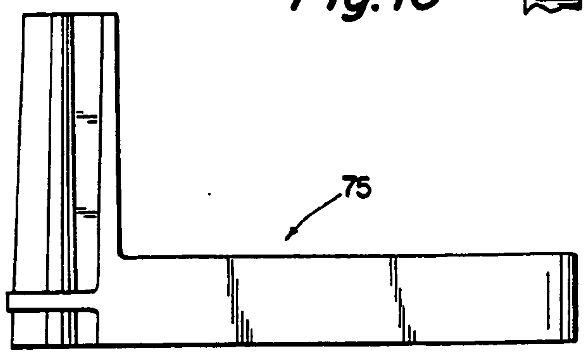
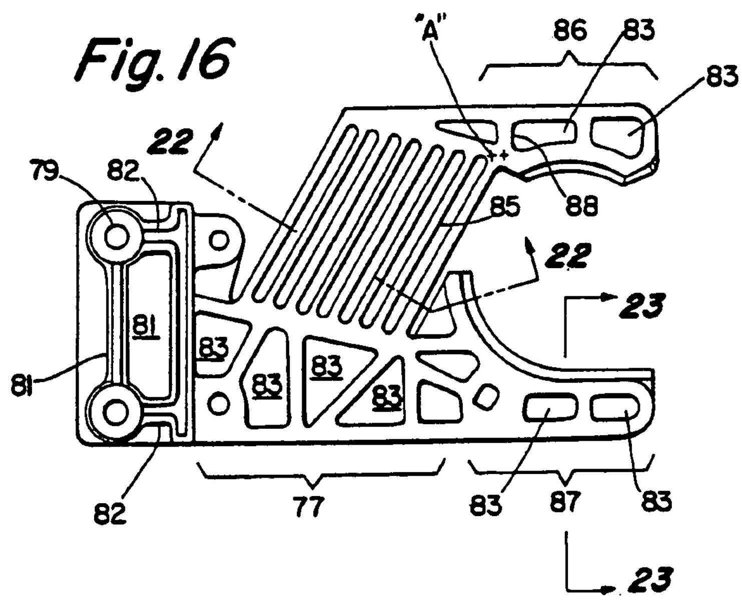
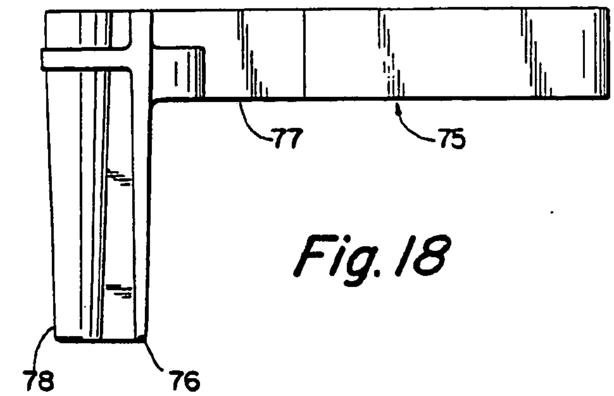


Fig. 17

Fig. 16





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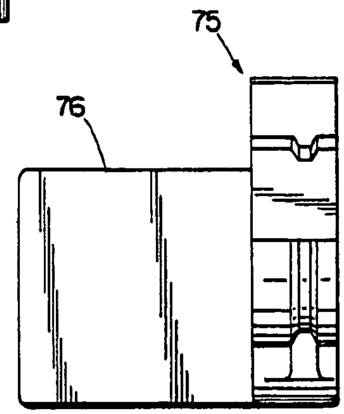

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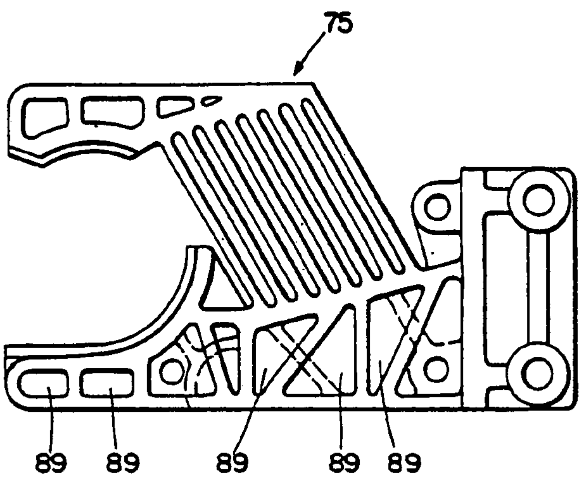

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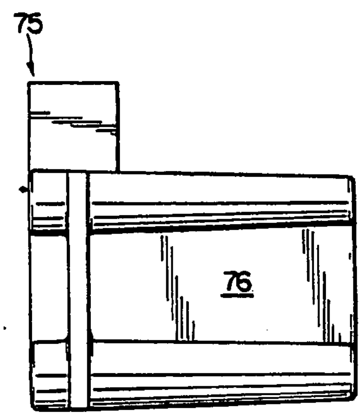

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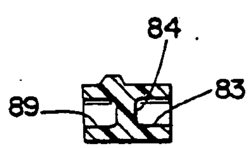

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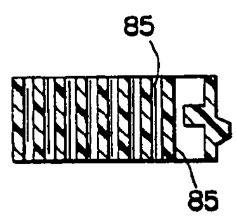

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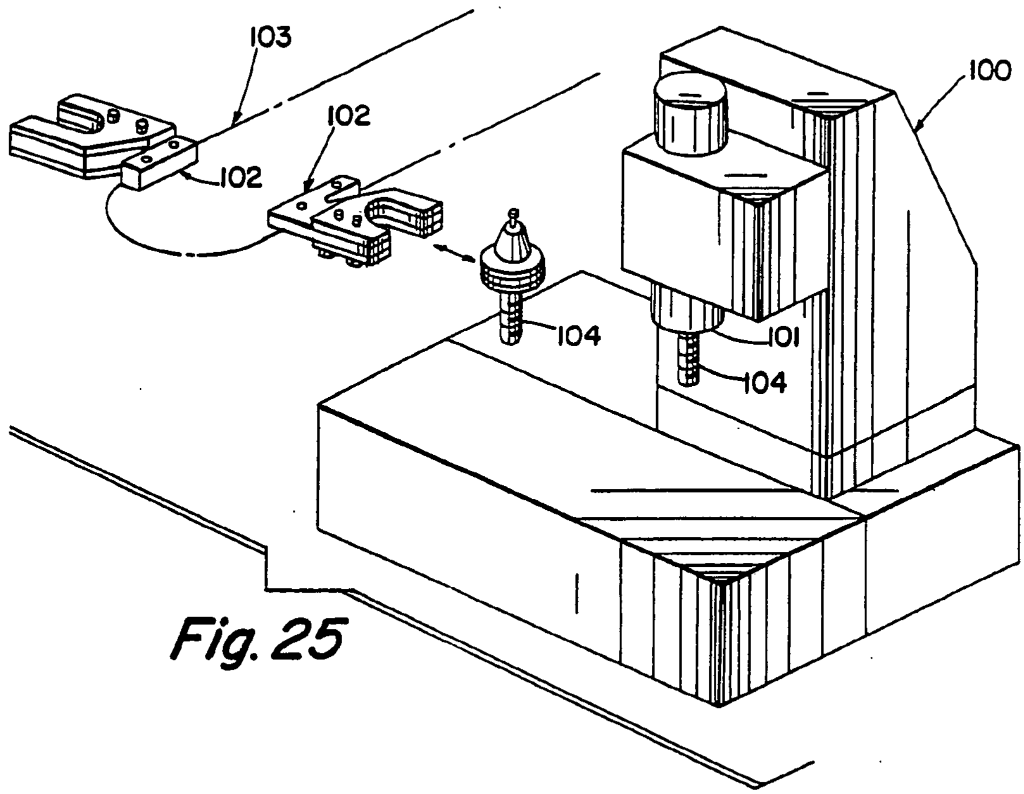

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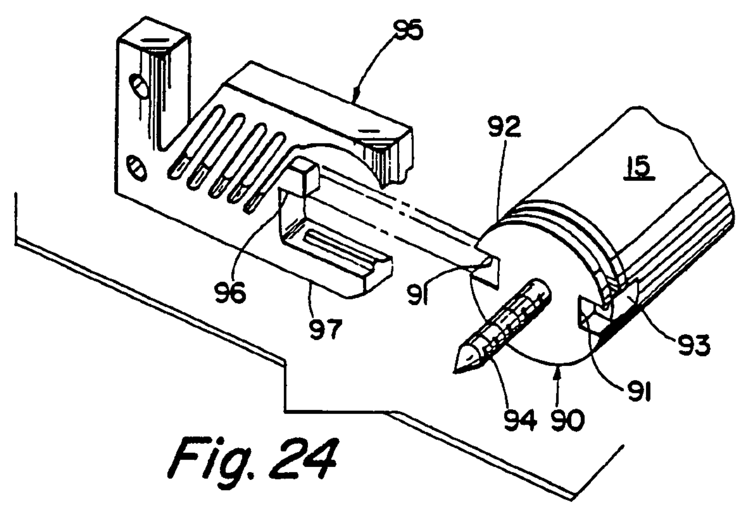

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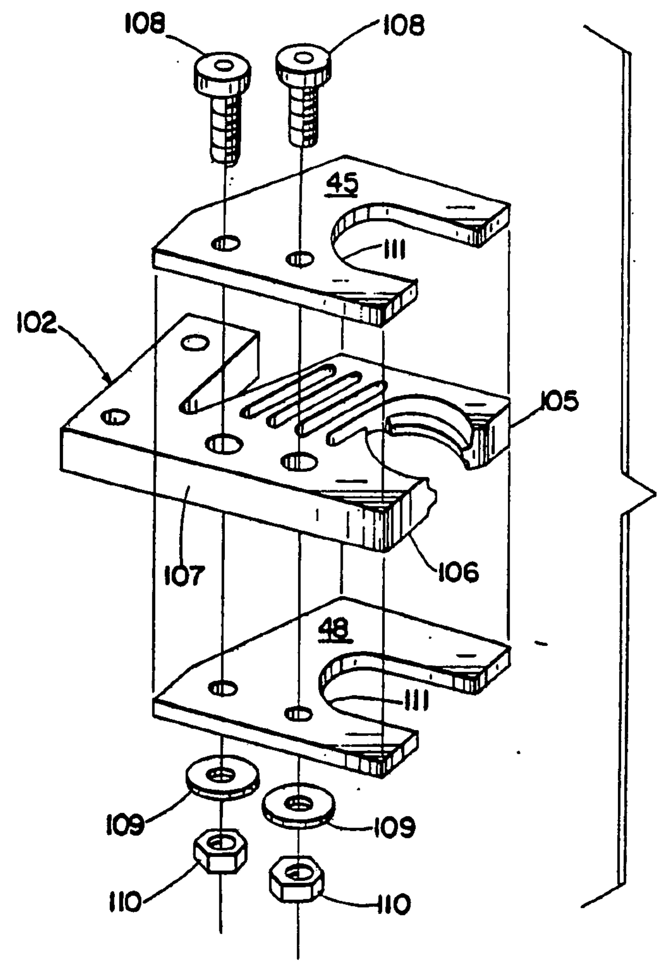
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Fig. 26

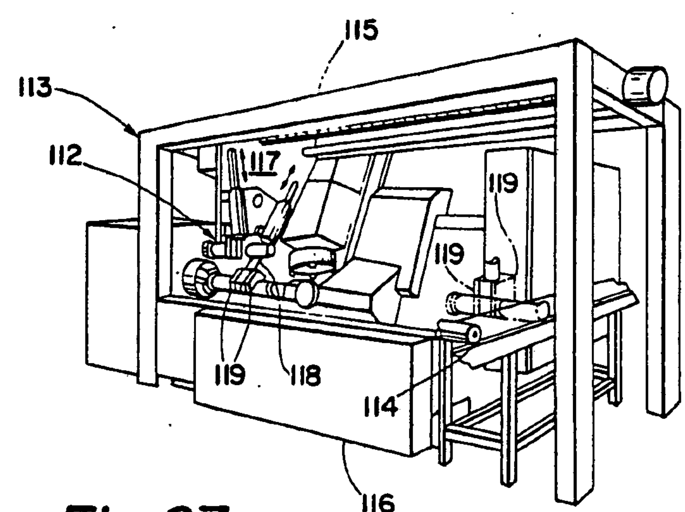
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Fig. 27